Appendix 2

2014 Abel Underground Coal Mine Dam Monitoring and Management Survey

(No. of pages including blank pages = 64)

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2014 Abel Underground Coal Mine Dam Monitoring and Management Survey

Yancoal Australia Pty Ltd

Abel Underground Coal Mine, Beresfield, NSW

January 2015

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2014 Abel Underground Coal Mine Dam Monitoring and Management Survey

Abel Underground Coal Mine, Beresfield, NSW

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EXECUTIVE SUMMARY

Donaldson Coal Pty Ltd commenced operating Abel Underground Coalmine at Beresfield in the lower Hunter Valley, New South Wales, during 2008. To comply with part of the conditions of consent a Flora and Fauna Management Plan was prepared (Ecobiological 2007). This identified the need to establish a Surface Ecological Monitoring Plan (SEMP), comprised of several different monitoring programs. This Dam Monitoring and Management Plan (DMMP) is one of the monitoring programs.

In 2008, baseline ecological data was recorded at 156 dams in the Abel underground mine area (Ecobiological 2008). As well, assessment of the habitat value of dam sites for threatened fauna and flora was undertaken so that future monitoring could target dams which exhibited habitat that may potentially support target threatened species. This report builds on the baseline information collected in previous surveys regarding the occurrence of threatened and non-threatened species at the targeted dams.

Over time, the number of participants (land holders) with surveyed dams has declined due to a range of factors including lack of interest and changing ownership. In 2014, only 50 dams were surveyed for amphibians out of a possible 66 dams surveyed in 2008, only two out of the four dams were surveyed for Blue-billed Duck, and only 57 dams out of the original 87 were surveyed for Maundia triglochinoides*.*

Species diversity and composition data for frogs, in addition to abundance for water-dependent bird species, at each of the targeted dams were recorded for the 2014 survey. These data provide a means of measurement and evaluation of potential subsidence impacts at each of the dams over time. The data collected over the last seven years will enable evaluation of potential subsidence impacts in the future.

At the time of the 2014 surveys, mining is taking place below several of the dams. The likelihood of ecological impacts from subsidence being detected at this early stage is low. As such, the data compiled in this report are considered to be a continuation of sampling under baseline conditions. Depending on the extent of mine development, future surveys will need to examine data for changes in baseline ecological conditions that could be attributed mine impacts.

Frog species diversity in 2014 was the lowest recorded over the seven years of survey. These results are similar to the 2009 and 2012 findings which correlate with relatively low

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rainfall during the breeding season for frog species. The higher rainfall experienced during the months leading up to breeding season in 2010, 2011 and 2013 may have contributed to the higher calling activity and presence around breeding sites (dams). In years where rainfall has been higher (2010, 2011 and 2013), an increase in frog diversity was experienced across a number of dams to levels comparable or greater than the 2008 survey results. The survey results from 2009, 2012 and 2014, where the rainfall has been lower, showed a decrease in frog species diversity from the 2008 survey results. Trends such as this can help identify when changes in fauna species diversity are the result of natural fluctuations or from human induced impacts.

Total bird diversity over the survey period decreased in 2014 but still was above average with four new species being detected. Fifty-two (52) species have now been observed within the four dams surveyed in previous years and the two dams surveyed in 2014. Surveys conducted in 2014 had the second highest bird diversity recorded over the seven year survey period at Dam 7 and the third highest recorded diversity at Dam 14. This follows an increase in diversity observed in 2012 and 2013 which marked a change in a general decline at all dams from 2008 to 2011. High bird diversity and abundance may be in response to drier conditions in inland Australia which have concentrated birds to the coast where conditions are more favourable.

No threatened frogs or birds were identified. No individuals of the threatened plant, Maundia triglochinoides *were identified.*

Monitoring will continue until one year after mining has passed the Long Gully and Blue Gum Creek catchments. The information and management recommendations from these and other surface monitoring studies will then be available to inform best practice measures to be incorporated into the Subsidence Management Plan (SMP).

Surveys of water quality, water level, conditions and habitat suitability assessment at each dam, particularly those which have not yet been undermined are strongly recommended. These data will be important for differentiating mining impacts from other factors that effect the composition and abundance of frog and water bird species at the target dams.

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1. INTRODUCTION

Donaldson Coal Pty Ltd (Donaldson) commenced operations at an underground mine (Abel) in 2008, approximately 23 kilometres north-west of Newcastle. The mine will extract up to 4.5 million tonnes per year over 21 years using high productivity continuous miner based bord and pillar systems, and pillar extraction techniques. The seams to be mined are located under the Black Hill rural and adjoining forested areas. Mine access and associated surface infrastructure is located within the existing Donaldson Coal mine open cut void at Beresfield, with transfer of coal to the existing Bloomfield Coal Handling and Preparation Plant (CHPP), immediately to the north, for coal washing and rail transport to the Port of Newcastle.

Underground coal mining is often associated with adverse environmental impacts because of subsidence (Bell *et al*. 2000, Sidle *et al*. 2000). Subsidence can cause loss of productive land, damage to underground pipelines and above-ground structures, decreased stability of slopes and escarpments, contamination of groundwater by acid drainage and dewatering of streams and groundwater supplies (Sidle *et al*. 2000). Of these, one of the major environmental concerns arising from the Abel mine is the effect of subsidence on local and regional hydrology. Surface and sub-surface cracking associated with mining subsidence can alter and create preferential flow paths, thus causing dewatering and rerouting of surface water and groundwater (Sidle *et al*. 2000). Alterations in channel and drainage morphology may also affect channel erosion, sediment delivery, and routing in streams and riparian habitat.

Associated with development approval for the Abel coalmine were a number of conditions of consent. These conditions included a requirement for the preparation of a Flora and Fauna Management Plan (F & FMP) which was prepared by Ecobiological (2007). The F & FMP, which forms part of a comprehensive Environmental Management System for the Abel mine, sets out a strategy to monitor the effectiveness of the conservation measures proposed in the Environmental Assessment (EA) Statement of Commitments for the overall operation of the mine.

Part of this strategy was to establish a Surface Ecological Monitoring Plan (SEMP) to monitor the effectiveness of the conservation measures proposed in the EA to mitigate against subsidence impacts on three distinct habitat areas; farm dams that form a belt across the mine site; subtropical rainforest areas of Long Gully Creek; and Pambalong Nature Reserve.

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The SEMP outlines a monitoring program for each of these areas by which baseline and subsequent monitoring data are to be gathered to inform future management. This report builds upon the baseline report for the Dam Monitoring and Management Program (DMMP) which forms part of the overall SEMP.

The Dam Monitoring and Management Plan (DMMP) gathered data for 156 dams in 2008, all of which are located above the Abel underground mining area. In 2009, the number of dams identified for longer-term monitoring was reduced to 84, following assessment of their habitat suitability for the threatened Green and Golden Bell Frog (*Litoria aurea*), Green-thighed Frog (*Litoria brevipalmata*), Blue-billed Duck (*Oxyura australis*) and the aquatic plant *Maundia triglochinoides*. Preferred habitat of each is detailed in **Appendix 1**.

Over time, the number of participants (land holders) with surveyed dams has declined due to a range of factors including lack of interest and changing ownership. Sixty-four (64) dams with suitable Green and Golden Bell Frog habitat were surveyed for this species in 2008 and 2009, 61 dams in 2010 and 2011, 65 in 2012 and 2013, and 50 in 2014. Thus fluctuations of surveyed dams are largely a result of private landholders preventing access to their land.

Eighty-seven (87) dams were originally assessed as containing suitable habitat for the aquatic plant *M. triglochinoides*, but with knowledge gained from past surveys this number has been reduced; only 57 dams were surveyed in 2014.

Species diversity, abundance and composition data for water-dependent bird species at four of the dams containing preferred habitat have historically been recorded since 2008, however only two dams were surveyed in 2014 due to lack of access. These data provide a means of measurement and evaluation of potential subsidence impacts at each of the dams over time to later be incorporated into the SMP.

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2. LOCATION

The Abel Underground Mine is located within Newcastle, Cessnock and Maitland local government areas (LGAs). The majority of the underground mine and surface infrastructure area is within the Cessnock LGA.

The location of the underground mine area, surface facilities and the current extent of the underground mine are shown in **Figure 1**. The underground mine area is bounded on the eastern side by the F3 Freeway; the western and southern sides by a tract of forest that extends south to the Central Coast and beyond to Hornsby and to the northern side by existing open cut coal mining activities within the Donaldson and Bloomfield mine leases.

The Abel underground mine area is approximately 2750 ha and consists of low undulating forested hills with patches of cleared land for 110 rural/residential properties. Approximately 175 farm dams are located above the underground mining area, scattered across these various properties. Large areas of land are owned by Donaldson Coal, Coal and Allied (Rio Tinto) and the Catholic Diocese of Maitland and Newcastle. Black Hill Public School, various local roads and other infrastructure are located in the area.

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CHPP
NEW ENGLAND HWY
BLOOMFIELD OPEN CUT
DONALDSON OPEN CUT
JOHN RENSHAW DRIVE
Black Hill Road
ABEL UNDERGROUND MINE AREA
F3 FREEWAY
Blue Gum Creek
Figure 1 - Dams Locations Within Project Area
Legend
Dam Monitoring Locations
Project Application Area
Current Extent of Underground Mine (Dec 2014)
Abel Surface Facilities
0
2 km
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Coordinate System: Australia MGA94 (56)
Datum: Australian Geocentric 1994 (GDA94)
Projection: UTM 56
ecobiological - January 2012
Nearmap - 2014

3. OBJECTIVES

The Abel EA submission notes that the 175 dams located above the underground mining area are vulnerable to subsidence impacts such as cracking or tilting with significant water loss as a result. The DMMP aims to develop a set of data for 87 of these dams (**Appendix 2**) focusing on sensitive flora and fauna (targeting threatened species), species diversity, composition and abundance to inform the SMP. **Figure 2** shows the location of the accessible dams across the mine area in 2014 as well as other significant surface features. **Figure 3** shows the dams not accessible in 2014 due to landowner disinterest.

Table 1 sets out the target threatened species, appropriate methods and monitoring times as outlined in the F & FMP.

Table 1 Species targeted by the Dam Monitoring and Management Plan.

Scientific name	Common Name	Method	No. of Dams	Monitoring Period
Litoria aurea	Green and Golden Bell Frog	Call playback and targeted search	64	Warm nights during or after rain (October – February)
Litoria brevipalmata	Green-thighed Frog	Targeted search	3	Warm nights after heavy rain (October – February)
Oxyura australis	Blue-billed Duck	Targeted search	4	Summer
Maundia triglochinoides	-	Targeted search	87	Late spring to early autumn

Table 2 Species targeted by the Dam Monitoring and Management Plan in 2014

Scientific name	Common Name	Method	No. of Dams	Monitoring Period
Litoria aurea	Green and Golden Bell Frog	Call playback and targeted search	50	Warm nights during or after rain (October – February)
Litoria brevipalmata	Green-thighed Frog	Targeted search	2	Warm nights after heavy rain (October – February)
Oxyura australis	Blue-billed Duck	Targeted search	2	Summer
Maundia triglochinoides	-	Targeted search	57	Late spring to early autumn

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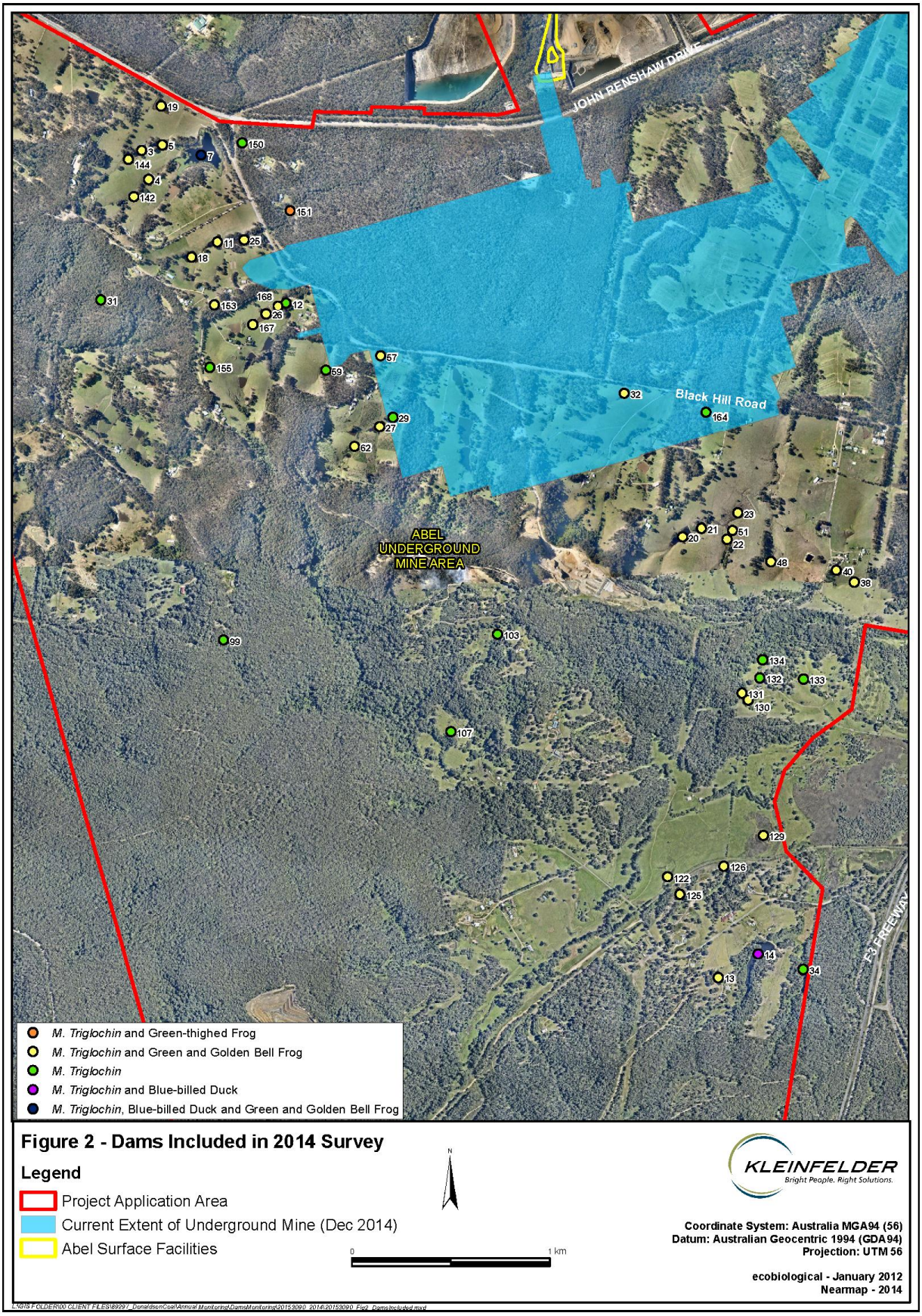
JOHN RENSHAW DRIVE
Black Hill Road
ABEL UNDERGROUND MINE AREA
F3 FREEWAY
M. Triglochin and Green-thighed Frog
M. Triglochin and Green and Golden Bell Frog
M. Triglochin
M. Triglochin and Blue-billed Duck
M. Triglochin, Blue-billed Duck and Green and Golden Bell Frog
Figure 2 - Dams Included in 2014 Survey
Legend
Project Application Area
Current Extent of Underground Mine (Dec 2014)
Abel Surface Facilities
N
0
1 km
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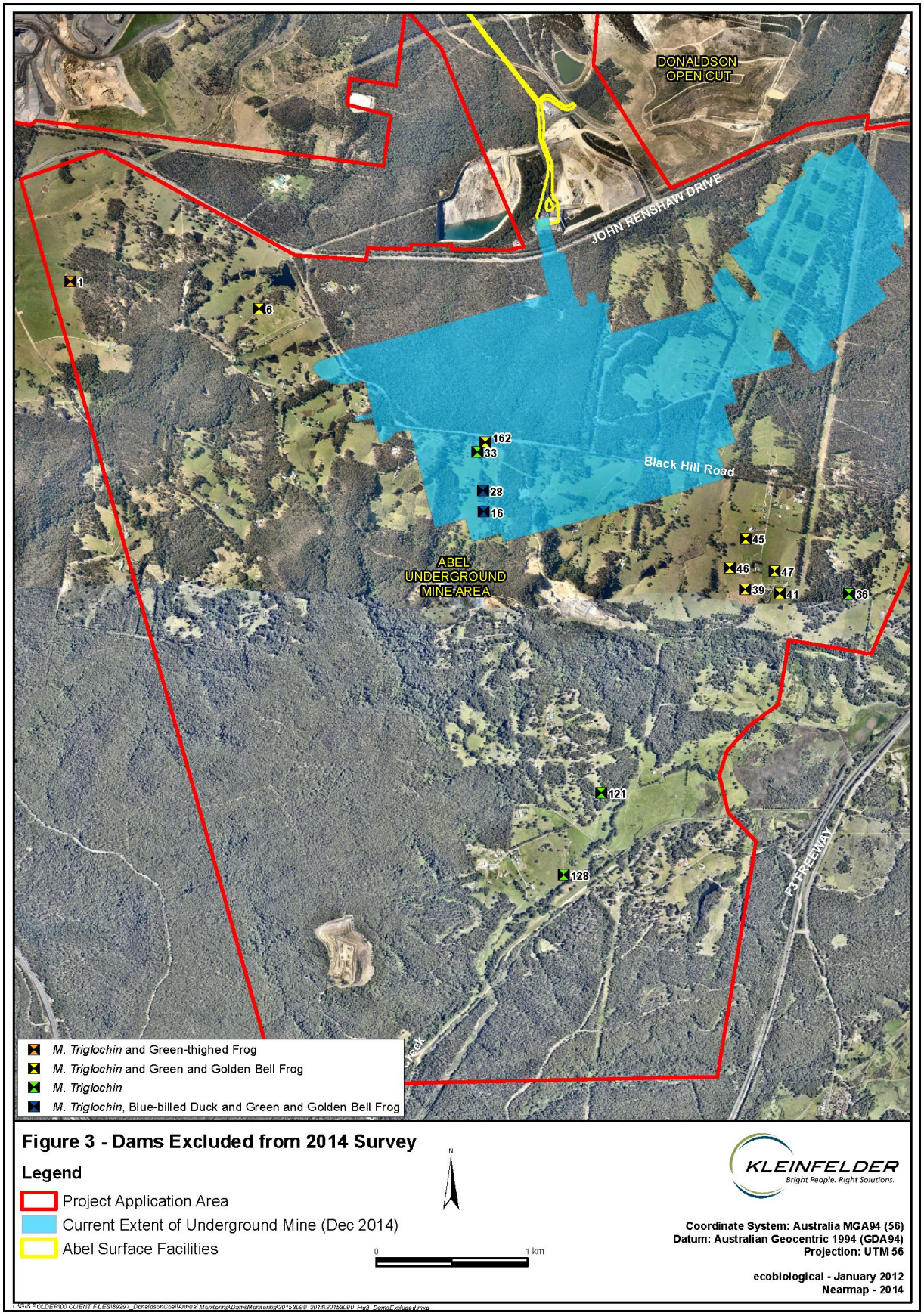
Coordinate System: Australia MGA94 (56)
Datum: Australian Geocentric 1994 (GDA94)
Projection: UTM 56
ecobiological - January 2012
Nearmap - 2014


DONALDSON OPEN CUT
JOHN RENSHAW DRIVE
Black Hill Road
ABEL UNDERGROUND MINE AREA
F3 FREEWAY
1
6
162
33
28
16
45
46
47
39
41
36
121
128
M. Triglochin and Green-thighed Frog
M. Triglochin and Green and Golden Bell Frog
M. Triglochin
M. Triglochin, Blue-billed Duck and Green and Golden Bell Frog
Figure 3 - Dams Excluded from 2014 Survey
Legend
Project Application Area
Current Extent of Underground Mine (Dec 2014)
Abel Surface Facilities
N
0
1 km
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Datum: Australian Geocentric 1994 (GDA94)
Projection: UTM 56
ecobiological - January 2012
Nearmap - 2014

4. METHODS

4.1 AMPHIBIANS

4.1.1 Green and Golden Bell Frog (*Litoria aurea*)

Sixty-four (64) dams with suitable Green and Golden Bell Frog habitat were surveyed for this species in 2008 and 2009, 61 dams in 2010 and 2011, 65 in 2012 and 2013, and 50 in 2014. Fluctuations of surveyed dams are a result of private landholders preventing access to their land.

Surveys in 2014 were conducted on the 12th – 16th January 2015. Although numbers of available dams had dropped since 2013, the 50 dams surveyed in 2014 were located where underground mining is currently occurring and areas where mining will occur in the future. As such, the dams surveyed were considered to be suitably representative of the total dams present and provided the best practicable opportunity of detecting the Green and Golden Bell Frog.

Threatened species survey guidelines for target species (DEWHA 2009) require surveys to be completed during warm and windless weather conditions following rainfall. During the 2014 survey period maximum daily temperatures ranged from 22.7-38.0°C with evening temperatures at an average of 23 degrees the conditions were calm at the time of surveys. Significant rainfall events occurred in December.

Both targeted habitat surveys and call playback surveys were conducted throughout the survey period. At each dam an initial two minute quiet listening period was carried out to see if any Green and Golden Bell Frogs were calling and to record any other common species heard. This was followed by 10 minutes of call playback and 10 minutes of habitat searching. During call playback, pre-recorded calls of the Green and Golden Bell Frog were broadcast over a megaphone to attempt to illicit a response from any males that may have been present.

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The call playback period generally consisted of around 1 minute of playing the calls followed by 20 seconds of quiet listening, repeated until the 10 minute period was complete. The habitat searches consisted of searching suitable habitat with the aid of a head-torch to locate any adults or juveniles. All other frog species observed were also recorded.

4.1.2 Green-thighed Frog (*Litoria brevipalmata*)

Three (3) dams were deemed potentially suitable for the Green-thighed Frog, however only two dams were available in 2014. Dam 87 and Dam 151 were surveyed for this species on the 12th January and the 13th January. Access could not be gained for Dam 1.

Surveys are required to be completed after heavy rainfall during the breeding season (November -February) (DECC 2009). A rainfall event occurred on the 11th January of 10.6mm followed by 21.6mm on the 12th January (Maitland weather station; Bureau of Meteorology, 2015).

Quiet listening and a habitat search were carried out for the Green-thighed Frog at each dam. The species only calls on a small number of nights (usually <5) in any given season and only after significant rainfall (usually 70mm). It does not readily respond to call playback. The habitat search consisted of searching suitable habitat with the aid of a head-torch to locate any adults or juveniles.

4.2 BIRDS

4.2.1 Blue-billed Duck (*Oxyura australis*)

Two dams were surveyed for the Blue-billed Duck on the 14th January 2015; Dams 7 and 14. Dams 16 and 28 could not be surveyed due to private landholders withholding access to the dams. Originally only four dams were considered to have suitable habitat for the Blue-billed Duck. The surveyed dams were chosen based on their size (with only large dams usually being inhabited by the species), the amount of deep, open water and the amount of fringing aquatic vegetation present.

Targeted surveys for the Blue-billed Duck involved a 20-minute walking transect along the edge of each of the selected dams. This time period enabled the inspection of the entire surface area of each dam for the target species. The surveys were carried out during clear

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and warm conditions. Individual counts of all other waterbird species observed utilising the surface of the water body or foraging either within the vegetated margins or aerially foraging over each dam was also recorded.

4.3 FLORA

4.3.1 Maundia triglochinoides

Eighty-seven (87) dams were originally assessed as containing suitable habitat for the aquatic plant *M. triglochinoides*, but with knowledge gained from past surveys this number has been reduced to 57 dams. Searches were conducted on the 20th and 21st of January 2015. Surveys were conducted by completely circumnavigating the edges of the dams on foot (where physically possible) ensuring that all water edge environments were searched. The surveys were conducted in January to coincide with the flowering time of *M. triglochinoides* as it is difficult to detect and distinguish from closely related species during the non-flowering period.

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5. RESULTS

5.1 AMPHIBIANS

No Green and Golden Bell Frogs were detected at any of the 50 dams surveyed. No Green-thighed Frogs were detected at the two dams containing suitable habitat for this species. No frogs listed under State or Commonwealth legislation were recorded during field surveys.

Six (6) non-threatened species of frog were detected at the dams during 2014 surveys (**Appendix 3**). All are considered to be common dam or pond breeding species. Eleven species were detected during 2013 surveys; eight during 2012; twelve during 2011; ten during 2010; and eleven during 2009 and 2008. All species detected in 2014 have been recorded in previous surveys.

Frog diversity is a measure of the number of species found in each dam. Between 2008 (initial survey) and 2009 there was a decline in frog diversity at most dams (N=47), that is more dams had less species each, although the total number of species detected was the same across all dams. However, 38 dams experienced an increase in frog diversity between the 2009 and 2010 surveys.

Between 2010 and 2011, 20 dams recorded an increase in frog species diversity, and 13 dams had the same diversity as the previous year. From 2011 to 2012 only 15 dams recorded an increase in frog species diversity while 31 dams decreased in diversity. From 2012 - 2013, 39 dams recorded an increase in frog species diversity, while 12 decreased, and 12 remained the same. From 2013 – 2014, 42 dams recorded a decrease in frog species diversity, while 6 remained the same and 2 increased from the previous year's survey. The distribution of frog species diversity for each survey year is shown in **Figure 4.**

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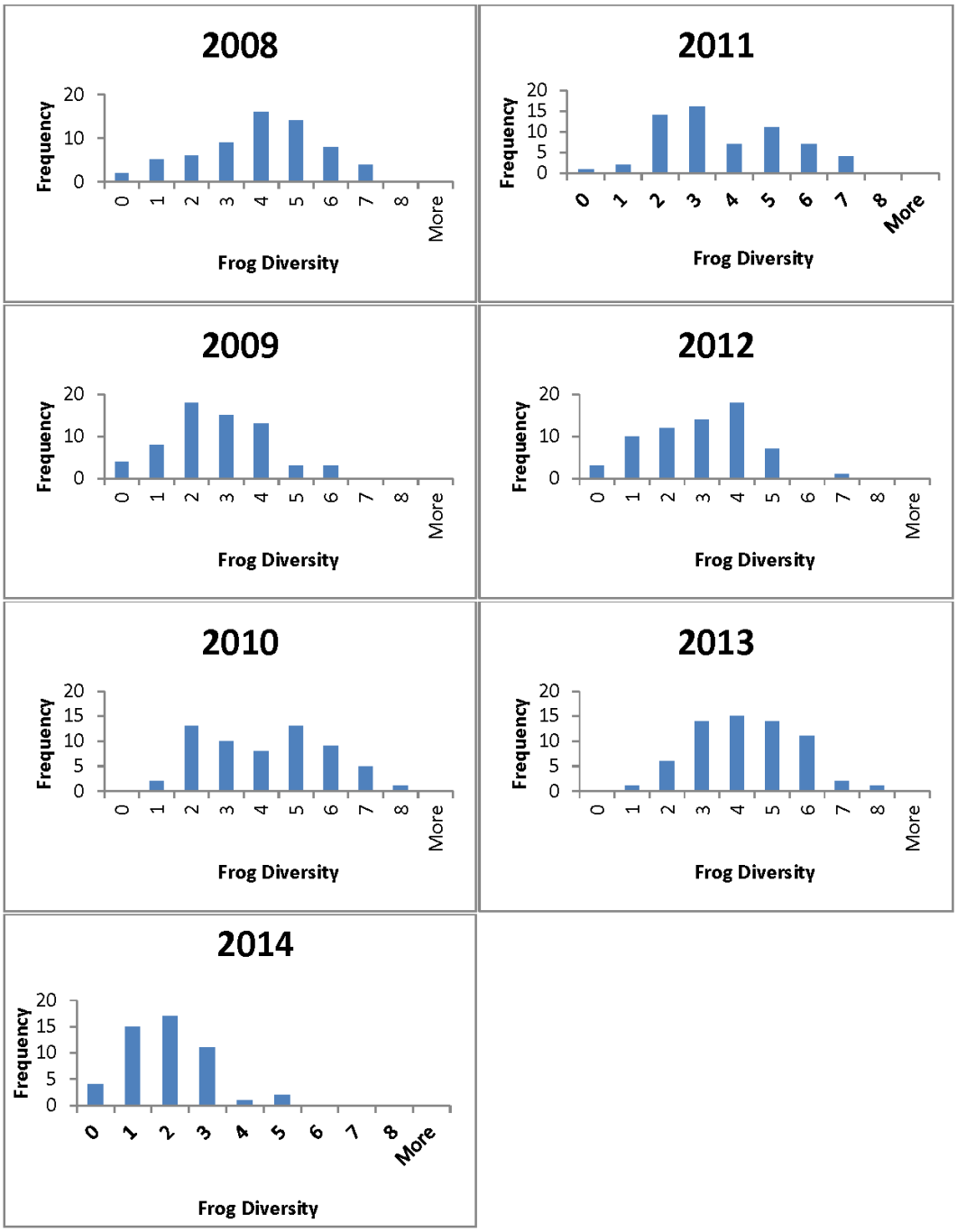

Figure 4 **Frequency distributions of the numbers of frog species recorded across all dams for each of the survey years 2008 – 2014.**

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The fluctuating numbers in frog species diversity over the last seven years likely reflects fluctuating weather patterns across the region. Abnormally warm conditions prevailed through much of November 2009 and average temperatures were above normal (National Climate Centre 2009) which may explain the drop in species diversity during the 2009 survey (**Figure 5**). Also, Donaldson Coal rainfall statistics for the region show an increased level of rainfall during the 2011 monitoring period which can be reflected in the increase in frog numbers during that survey (**Figure 6**). Rainfall data show that between September and December only 202.4 millimetres of rain fell in 2009; 334 millimetres in 2010 and 479 millimetres in 2011 (source: Maitland weather station Bureau of Meteorology 2014). In 2012 the lowest recorded rainfall was experienced between September and December (119.3 millimetres). In 2013 the second highest seasonal rainfall over the six years of the survey was recorded (450 millimetres). In 2014 the rainfall from September to December was recorded at 266 millimetres for the period: which is below the average from previous years with only two minor rainfall events the days before the survey.

It is likely that this combination of lower than normal rainfall and warmer temperatures, as experienced in 2009, 2012 and 2014, is the main contributing factor in the decreased frog species diversity as compared to 2011 and 2013. **Figures 5** and **6** show a general trend towards higher diversity for lower maximum temperatures and higher rainfall. In 2013 the results did not show a strong correlation between lower maximum temperature and frog richness per dam however though they do follow the trend of higher rainfall and higher frog diversity.

The 2014 data show higher average maximum temperatures at 27.5 degrees which is the second highest across the seven years. Rainfall in the September to December period was lower than average at 266 millimetres with only two rainfall periods of 10.6 millimetres and 21.1 millimetres immediately before the survey. From these data, both rainfall and temperature seem to be a strong influence in the results of the 2014 survey.

The list of frog species identified from each dam and the totals are shown in **Appendix 3.**

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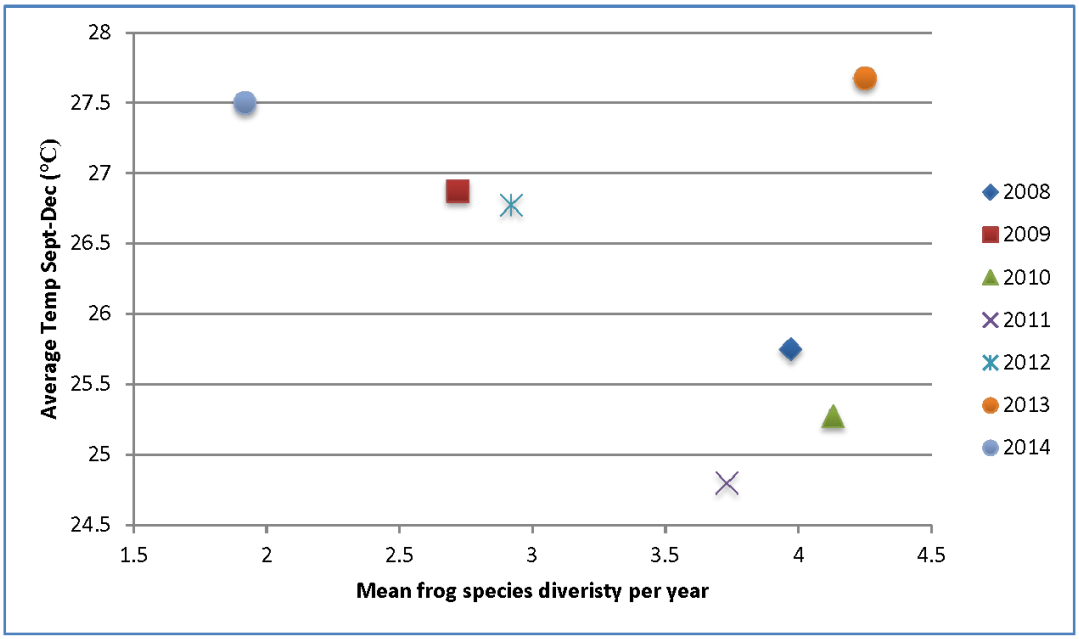

Figure 5 **The effect of temperature on numbers of frog species detected.**

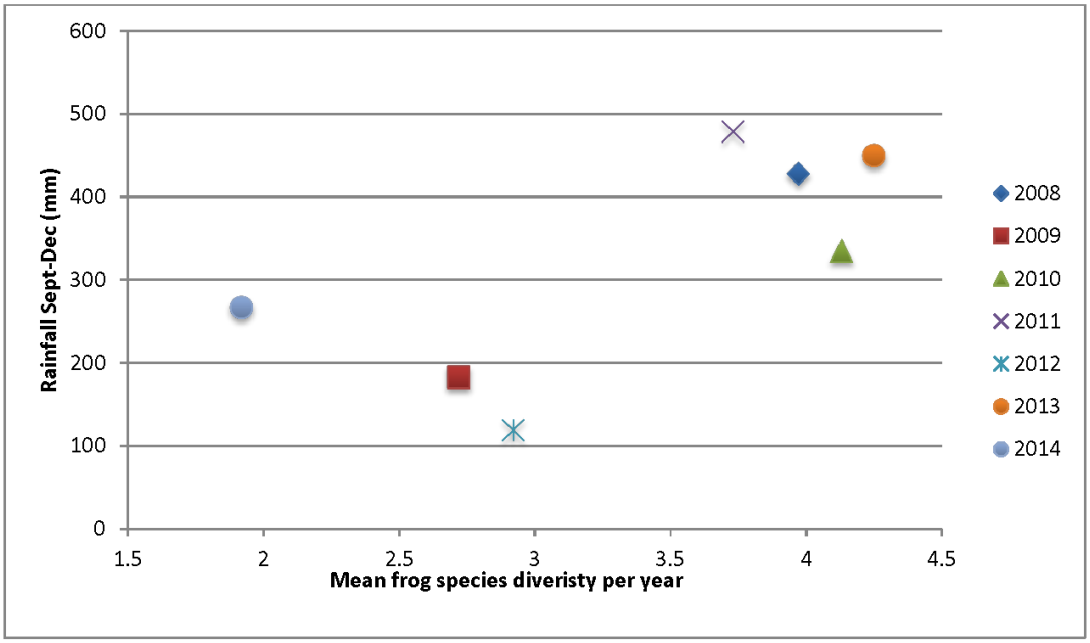

Figure 6 **The effect of rainfall on number of frog species detected.**

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5.2 . BIRDS

The Blue-billed Duck was not detected during 2014 surveys. As discussed in the methodology, only two of the four dams were surveyed due to access issues. No bird species listed as threatened under State or Commonwealth legislation were recorded during field surveys.

A total of 52 bird species have been recorded between 2008 and 2014 across all of the dams surveyed (**Appendix 4**). The 2014 surveys detected 21 species across the two dams, with nine species at Dam 7 and 13 species at Dam 14 (**Figure 7**). Four species not seen previously were recorded in 2014: White-breasted Wood-swallow, Latham's Snipe and an Eastern Whipbird (three species at Dam 7 and one at Dam 14).

The 2014 survey recorded the second highest species diversity at Dam 7 and third highest at Dam 14 since monitoring commenced. Between 2009 and 2011, Dams 7 and 28 show an overall declining trend in diversity; however from 2011 to 2014 there has been an overall increase in bird species at Dam 7. Dams 14 and 16 fluctuate considerably in the number of species recorded each year. Overall diversity has increased progressively over the last several survey events.

By comparison, the 2013 surveys detected 39 bird species across the four dams ranging from 11 to 21 species per dam. In 2012, 26 species were detected across the four dams, ranging from nine to 15 species per dam; in 2011, 13 species across the four dams with either five or six species detected per dam; in 2010, 10 species across the four dams with between one and seven species per dam; in 2009, 17 species with between six and 11 species per dam; and in 2008, 17 species with between three and 10 species per dam.

In 2014, the total abundance for Dam 7 was similar to previous years: bird abundance at Dam 7 is very similar across all years (**Figure 8**). The highest abundance at either dam in 2014 was 44 individuals; recorded at Dam 14 which is slightly below average.

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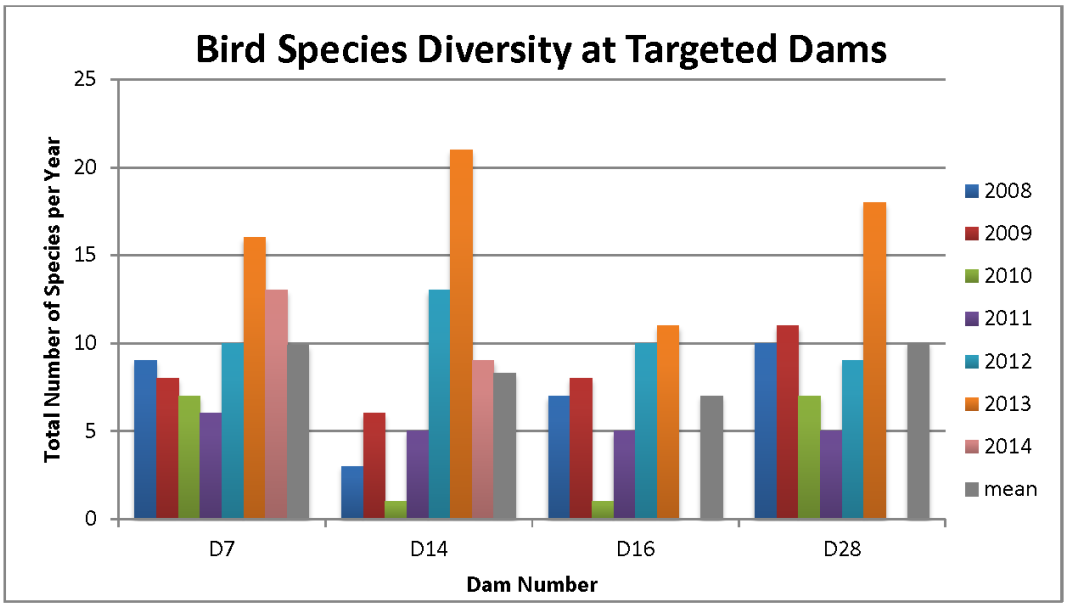

Figure 7 **Bird species diversity at surveyed dams.**

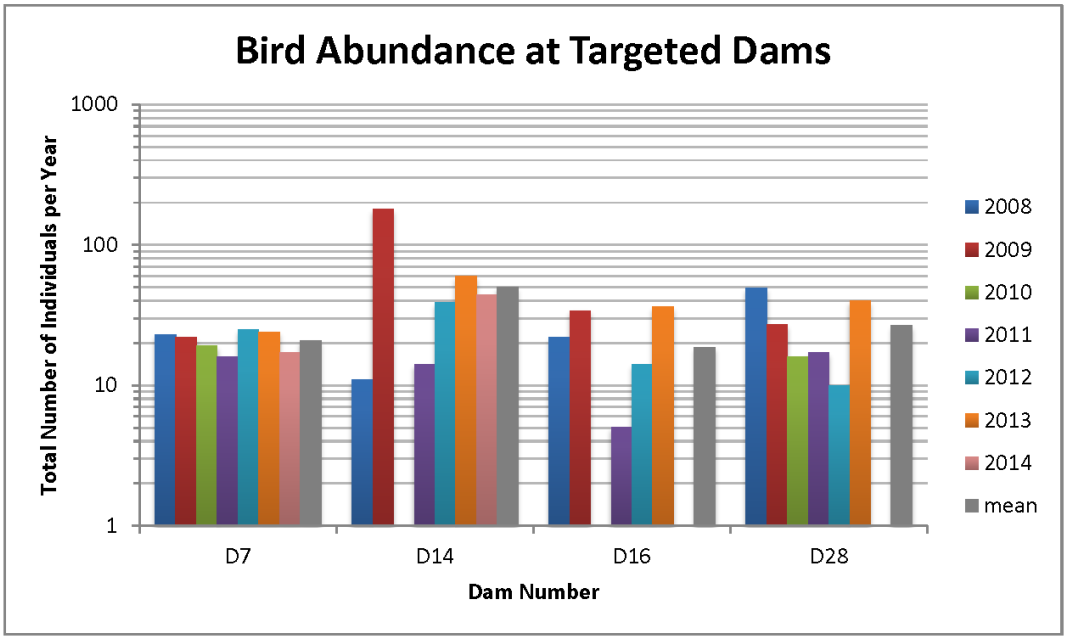

Figure 8 **Bird species abundance at surveyed dams.**

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5.3 FLORA

Maundia triglochinoides was not detected at any of the 57 dams surveyed. Permission to survey four dams was declined by the current owners (dams no. 93, 120, 121 and 128), while two owners did not respond to requests for permission to enter (Dam 6 and 36). No other flora species listed as threatened under State or Commonwealth legislation or under the ROTAP (Rare or Threatened Australian Plant) scheme were recorded during field surveys.

While *M. triglochinoides* was the main focus of the survey, the opportunity was also used to also assess the flora within the dams; one noxious water borne weed species - *Eichhornia crassipes* (Water Hyacinth) was identified in 14 of the dams during surveys.

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6. DISCUSSION

6.1 AMPHIBIANS

6.1.1 Green and Golden Bell Frog

While a third of all the dams identified and surveyed in 2008 were considered to contain suitable Green and Golden Bell Frog habitat, the species has not been detected in any of the seven surveys. However, habitat characteristics (increased turbidity, change in water depth and dam profile, changes in vegetation types and densities) of target dams have changed, or have been modified by landholders - altering the suitability of the habitat for the Green and Golden Bell Frog

The Green and Golden Bell Frog prefers large, permanent water bodies containing high levels of emergent vegetation such as Typha, Baumea and the introduced *Juncus acutus*. Some of the target dams surveyed did not contain any or some of the features required by the Green and Golden Bell Frog. Issues at some of the target dams included Water Hyacinth covering entire surfaces, no bank vegetation due to cattle grazing, or no open water.

Regardless of the current status of occupancy of dams by the targeted species, the presence of a large number of dams with habitat suitable for these species (particularly those that interconnect and form habitat complexes) is an important factor for their future recovery. This is particularly true for the Green and Golden Bell Frog, a relatively mobile species that is known to be able to travel considerable distances and traverse hostile habitats to reach suitable ones (Daly 1995).

Currently there are two recognised key populations of Green and Golden Bell Frog at opposite ends of Hexham Swamp (known as the Sandgate and Kooragang Island populations). The species was also once known to be widespread right through the Hexham Swamp and adjoining areas. Old records of this species are known from within a 10 kilometre radius of the Black Hill area; however these populations are now thought to be extinct (M. Mahoney pers. comm.). Nevertheless, should this species recover in the near future it is highly conceivable that it may migrate back through this area towards Pambalong Nature Reserve and onto the adjoining belt of farm dams.

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6.1.2 Green-thighed Frog

Ephemeral pools, partly or wholly within rainforest or wet sclerophyll forest are ideal habitat for the Green-thighed Frog. They also forage in and amongst fallen leaf litter and logs. Locally, the Green-thighed Frog is only known from two records approximately 13 km from the Black Hill area and is not known for its high mobility.

In 2008, only three dams were considered to contain suitable Green-thighed Frog habitat (Dams 1, 87 and 151). While the surveys carried out were scientifically robust, Green-thighed frogs are cryptic in nature: they may only call on one or two nights of the year (Lemckert *et al.* 2006) and are very difficult to detect on other nights.

Only two dams were available for survey in 2014: Dam 87 and Dam 151. Access was not granted for Dam 1. Additionally, impacts from cattle grazing in and around the two dams have also degraded the habitat and water quality. The two ponds which once contained suitable habitat for the Green-thighed Frog now represent habitat of little value for this species and, without habitat restoration, their presence in future surveys is not expected.

6.1.3 Non-threatened Frogs

The detection of numerous species of non-threatened frogs is a positive sign of ecosystem health. Amphibian calling activity recorded throughout the survey period was high, resulting in a high level of confidence that the majority of species present were likely to be detected.

Data from the 2014 survey indicate that species diversity has decreased, particularly from the 2013 survey results that were attributed to a higher than average rainfall. This is considered to be typical of natural fluctuation in frog species diversity; **Figure 5** shows a strong correlation between frog species diversity and rainfall in spring and early summer months; with lower rainfall in 2009 and 2011 resulting in lower frog diversity per dam than other years. The current survey in 2014 recorded the lowest frog diversity per dam over the seven years of surveys and had below average rainfall calculated from the past seven years. Additionally 2014 had the second highest average maximum temperature contributing to the lower frog species diversity.

When conditions are poor, frogs conserve energy by going into torpor and foregoing breeding. When conditions improve; i.e. when it rains, and the probability of reproductive

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success improves, the number of frogs observed will increase due to heightened activity and calling.

Some species of frog potentially occurring in the study area have not been detected in the seven years of surveys, particularly the Green Tree Frog *Litoria caerulea*, Bleating Tree Frog *Litoria dentata*, Ornate Burrowing Frog *Platyplectrum ornatum*, Pobblebonk *Limnodynastes dumerilii*, Haswell's Frog *Paracrinia haswelli*, Bibron's Toadlet *Pseudophryne bibronii* and Tyler's Toadlet *Uperoleia tyleri*. One species, the Red-backed Toadlet, *Pseudophryne coriacea*, was detected in 2008 at one dam site that was not selected for further monitoring.

The absence of these species, and the varying diversity and species composition at the dams over seven years, may be due to a variety of factors such as the health of the dam ecosystems (cattle disturbance is widespread), or the Chytrid fungus (a pathogenic fungus that is considered largely responsible for the recent global amphibian decline) (Berger *et al.*, 1998), unsuitability of local habitat, changing weather conditions, weed infested dams with little open water or just chance. *Gambusia holbrooki* (Mosquito fish) may also pose a great threat to frog eggs and tadpoles. Mosquito fish are known to breed quickly and adversely impact or even wipe out native tadpole populations (Anstis 2002). Mosquito Fish were detected in the majority of dams surveyed in 2014.

The number of frogs detected may not always reflect the total species present due to a sampling bias. Survey methods for amphibians are largely focused on detecting males as they vocalise to attract a mate. When conditions to breed are not appropriate males will refrain from calling, therefore reducing their detectability. However, they are still present in the environment but may not be as obvious compared to other years. The loss of 15 dams from the study sample in 2014 has also had an impact on the total diversity recorded in 2014.

6.2 BIRDS

During the 2008 baseline surveys, four dams were considered to contain potential Blue-billed Duck habitat. This species is considered to be an uncommon visitor to the Hunter region, and has been irregularly recorded from key sites including Walka Water Works, Oakhampton Heights (approximately 8 km north of the study area) and Deep Pond, Kooragang Island (approximately 13 km east of the study area). The Blue-billed Duck is a mobile species that may re-appear at suitable deep dams at any time given suitable conditions. This species is

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also known from the Bloomfield Dam (NSW Wildlife Atlas 2010) to the north of the Abel mine area. Only two dams were available for surveys in 2014 due to landholder restrictions.

In 2014, there was a slight decrease in bird species richness at Dams 7 and 14 from 2013; however 2014 was above the seven year average for both dams. In 2014, three species not previously recorded were identified; two species at Dam 7 and one species at Dam 14. Species abundance in 2014 was slightly below average for both dams.

It has been highlighted in past reports (ecobiological 2008, 2009, 2010, 2011 and Kleinfelder 2012, 2013) that bird diversity varies with rainfall in the area prior to surveys.

In 2014 inland NSW experienced widespread dry conditions during October and November with average rainfall during December (Bureau of Meteorology 2015). As such, many birds may have sought more favourable conditions by moving closer to the coast. The majority of birds that have been recorded to date are also nomadic/itinerant in that they often travel large distances and sporadically occupy multiple environments as they move. Birds of this nature are largely unpredictable in determining their specific movements and thus appear irregularly.

Collection of data on non-threatened bird species observed during the standardised surveys will be used to make comment on the ongoing health of the dam ecosystems into the future.

6.3 FLORA

While a third of all the dams identified and surveyed in 2008 were considered to contain habitat suitable for *Maundia triglochinoides*, this species was not detected in 2008, 2009, 2010, 2011, 2012, 2013 or in the 2014 survey period.

Only three records of *Maundia triglochinoides* in close proximity to the study area exist, one from Kooragang Wetlands (pers. obs., D. Pedersen), Irrawang Wetlands (pers. obs., Dan Pedersen) and the Medowie area, some 25 km from the Abel Mine site (NSW Wildlife Atlas, 2010). However, a close inspection of suitable dams over the six year period has not recorded this species. As this species mainly disperses via stream flow, it is unlikely that it will appear at any of the dam sites which are not generally connected to natural streams. It may also be dispersed by duck faeces; this however is a relatively unlikely occurrence.

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The presence of *E. crassipes* (Water Hyacinth) in several dams is of concern as they have the potential to spread to water ways downstream of the dams during times of high rainfall. This is a listed noxious weed (Class 3 in Maitland, Lake Macquarie and Newcastle Council areas) which state that the plant must be fully and continuously suppressed and destroyed.

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7. CONCLUSION

Frogs

Frog species diversity in 2014 was the lowest recorded over the seven years of survey, and had below average rainfall calculated from the past seven years. This pattern was similar to 2009 and 2012 which also had relatively low frog species diversity and rainfall during the breeding season. In years where rainfall has been higher (2010, 2011 and 2013), an increase in frog diversity was recorded across a number of dams to levels comparable or greater than the 2008 survey results. Trends such as this can help identify when changes in fauna species diversity may be the result of natural fluctuations or from human induced impacts. No targeted threatened frog species were recorded.

Birds

Total bird diversity over the survey period decreased in 2014 as compared to 2013, but was still above average with three new species being recorded. Fifty-two species have now been recorded from the four dams. Due to access restrictions, only two dams were surveyed in 2014 which had the second highest bird diversity recorded over the seven year survey period at Dam 7 and the third highest recorded diversity at Dam 14. This follows an increase in diversity observed in 2012 and 2013 which marked a change in a general decline at all dams from 2008 to 2011. High bird diversity and abundance may be in response to drier conditions in inland Australia which have concentrated birds to the coast where conditions are more favourable.

No Blue-billed Ducks, the targeted threatened species, were recorded.

Maundia triglochinoides

The data collected over the last seven years will enable evaluation of potential subsidence impacts in the future. At the time of the 2014 surveys, mining had begun below several of the dams. The likelihood of ecological impacts from subsidence being detected at this early stage is low. As such, the data compiled in this report are considered to be a continuation of sampling under baseline conditions. Depending on the extent of mine development, future surveys will need to examine data for changes in baseline ecological conditions that could be attributed to mine impacts.

No individuals of the threatened plant, *Maundia triglochinoides*, were identified.

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More detailed statistical analyses will be appropriate following the 2015 annual monitoring event to evaluate impacts arising from the mine expansion currently occurring in the study area. An accompanying water quality and condition assessment of the target dams is recommended to identify factors, such as eutrophication, recent fertiliser applications or nutrient runoff and local surface runoff. Any of these factors may impact species abundance and diversity.

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8. RECOMMENDATIONS

It is recommended that in future amphibian surveys, water quality and aquatic habitat assessments of the relevant dams be made to determine if any future changes in frog diversity or species composition at the dams may be explained by local environmental factors. Indices of water quality that can be collected with minimal cost and effort include temperature, pH and salinity (EC) as well as visual observations of water and aquatic vegetation health.

It is also recommended that the habitat suitability for Green and Golden Bell Frogs and Green-thighed frogs at each dam be reassessed as habitat characteristics have changed over time. This will assist in the future to identify factors, such as eutrophication of dams from stock, recent fertiliser applications, or nutrient runoff from farming practices and local surface runoff which may contribute to local frog and bird decline rather than effects from mining.

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APPENDIX 1. TARGET SPECIES PROFILES

Green and Golden Bell Frog (*Litoria aurea*)

The Green and Golden Bell Frog is a large frog with a robust body form ranging from 45mm to 110mm in size. Diagnostic features include a gold or cream-white stripe running along the side, extending from the upper eyelids to groin, with a narrow dark stripe beneath which runs from the nostril to the eye (DEC 2005). The body colour varies; it is usually a vivid pea green with splotches of metallic brown or green and a bluish green colour on the inside of the thighs. Some individuals may have an entirely green back, but this is variable and others may be primarily covered in the metallic markings.

This species was once one of the most common frog species on the east coast of Australia. It inhabited many lentic freshwater habitats throughout its distribution which occurred predominately along the coast but also extending as far inland as Bathurst and along the highlands in the north and south of the state (White and Pyke 1996). The Green and Golden Bell Frog has undergone a widespread and unexplained range contraction since the mid 1970's and the species is now listed as endangered under the *Threatened Species Conservation Act 1995,* NSW (TSC Act) and as vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999* Cth, (EPBC Act). It is currently restricted to isolated pockets along the coast throughout its former range with only one known remaining highland population at Queanbeyan.

The habitat preference and requirements of the Green and Golden Bell Frog are not well understood and difficult to define (Mahony 1999) resulting in some disagreement and confusion. Some of the differing views on its ecology may be due to a failure to take into account the role of the pathogenic Chytrid fungus that is thought to be primarily responsible for changes in the frog's distribution and abundance in the last two decades (Berger *et al.* 1998).

The species uses different habitat components throughout the various stages of its life cycle including different breeding, foraging and refuge habitats and has been known to disperse several kilometres between these various habitats. Generally large, permanent water bodies containing high levels of emergent vegetation such as Typha, Baumea and the introduced *Juncus acutus* are favourable habitat for the Green and Golden Bell Frog, however it has been observed using a wide range of natural and man-made water bodies including; coastal swamps, marshes, dune swales, lagoons, lakes, estuary wetlands, riverine floodplain wetlands, billabongs, storm water retention basins, farm dams, bounded areas, storage tanks, water troughs, drains, ditches and other excavation areas capable of capturing water such as quarries and brick pits (DEC 2005).

Terrestrial habitat attributes that appear to favour the species include large grassy areas associated with adjacent cover from logs, rocks or tussock forming vegetation that provide shelter. There also appears to be a preference shown to habitat containing a complexity of terrestrial and aquatic vegetation structure (Hamer *et al.* 2002). The introduced mosquito

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fish, *Gambusia holbrooki*, is believed to feed on small tadpoles; habitat which is free of these fish is preferred (White & Pike 1996)

The Green and Golden Bell Frog is frequently active during the day and night during warmer months and can often be observed sitting in emergent vegetation well above the water level (0.5-1m). It has also been observed well away from water altogether. The breeding period generally occurs between September and March although reproductive behaviour has been noted to occur between late winter and early autumn (DEC 2005a). Breeding events occur most often during, and just after, heavy rain events with a peak around January/February when summer storms are common. Males call while floating in the water or from pond-side vegetation mostly at night but will occasionally call during the day. Individuals or small groups of males often respond to call play back or call imitation.

Green-thighed Frog (*Litoria brevipalmata*)

The Green-thighed Frog was only discovered in 1970, originally at Wauchope, NSW and later in the Gosford area (Barker & Grigg 1977). It reaches around 40mm in length and is chocolate brown on the dorsum with yellowish lower flanks. A dark stripe runs from the snout, through the eye and tympanum and ends in the flank. The groin and backs of thighs are a distinct bright blue-green with black flecks throughout and the belly is pale cream (Robinson 1998). The Green-thighed Frog is listed as vulnerable under the TSC Act.

It is found in forests and swamps of the coast and adjacent ranges from central New South Wales to south east Queensland (Cogger, 2000; Hines *et al*. 1999). Its habitat requirements have remained highly cryptic for a long time with breeding noted to take place after heavy summer rains in rainforest and wet sclerophyll forest but also around temporary and semi-permanent ponds, flooded ditches and swamps including areas such as roadsides and power easements.

More recent research however has shed some light on the biology of this highly cryptic species, particularly in relation to its breeding habitat requirements and calling behaviour. In a study by Lemckert *et al*. (2006) it was found that over 90% of breeding sites consisted of ephemeral pools, partly or wholly within rainforest or wet sclerophyll forest (84% of the time). There are however some records from around permanent, artificial ponds within dry sclerophyll forest, and a small number from coastal forests and swamps. Natural depressions adjacent to streams (e.g. old billabongs) are the most commonly used calling sites, although breeding also occurs in artificial water bodies such as human excavated hollows and flooded road verges (around half of sites recorded). These pools are usually either leaf or shrub filled depressions, or have significant amounts of grass in and around them (Lemckert *et al*. 2006).

The duration of calling events for the species is brief, lasting for a median of only one night and a mean of 1.4 nights (Lemckert *et al*. 2006). Calling occurs between September and May, although greater than 90% of all calling activity occurs between November and February, with between 1 and >100 males calling (most commonly 2-10 individuals) (Lemckert *et al*. 2006). The species in the southern part of its range often displays only one calling event in a season, with two calling events observed on only four occasions in a study by Lemckert *et al*. (2006), and three calling events in a season observed only once. The maximum total recorded number of nights of calling activity at any site in a season in

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the 2006 study was five, with only one day or less per season recorded 80% of the time, indicating that the Green-thighed Frog has the lowest number of calling days of any temperate Australian anuran species (Lemckert *et al.* 2006). Calling is likely to occur only after rainfall events that are significantly above the mean daily or three daily levels for the given time of year (when it is more likely that flooding will occur in breeding ponds), and it is believed that the flooding of the breeding pools is the significant factor in calling behaviour, rather than the intensity of the rain itself.

The majority of Green-thighed Frogs are found within 100m of a tract of natural vegetation >20ha in size and none were found in the 2006 study (Lemckert *et al.* 2006) to occur in largely cleared (>50%) grazing lands or within entirely urban areas. While broad scale habitat clearing is a clear threat for this frog, it appears that partial clearing of vegetation within an area does not prevent Green-thighed Frogs from calling at a site and that they may have some tolerance for disturbance (Lemckert *et al.* 2006). Fire, particularly high-intensity fire, is also listed as a potential threat to the Green-thighed Frog, especially when associated with multiple disturbance events in rapid succession (Lemckert *et al.* 2006).

Blue-billed Duck (*Oxyura australis*)

The adult male Blue-billed Duck has a slate blue bill with a glossy black head and neck. The back and wings are a rich chestnut and the tail coverts are a black-brown. During the summer breeding season the bill of the male turns bright blue (DEC 2005b). The adult female has a grey-brown bill with plumage darker than the male with each feather barred with narrow bands of light brown. Juveniles are similar to the adult female but paler with a grey-green bill (Marchant & Higgins 1990).

Preferred habitat is large, deep, well-vegetated swamps where they spend almost all of their time in the water, often in large flocks. Occasionally the species can be found using creeks, rivers and farm dams for foraging and breeding (Frith 1982). The Blue-billed Duck feeds on the surface of the water or by diving for aquatic insects such as chironomid larvae, caddis flies, dragonflies, damselflies, flies and water beetle larvae (Schodde & Tidemann 1986).

The Blue-billed Duck is endemic to Australia occurring mainly within temperate wetlands of the south-eastern and south-western parts of the continent (Marchant & Higgins 1990). The Blue-billed Duck has also been reported from central Australia and Tasmania with little change in reporting rate over the last 20 years (Barrett *et al.* 2003). The Blue-billed Duck is listed as vulnerable under the TSC Act. Nationally the Blue-billed Duck is classed as of 'least concern' because of the very large flocks that inhabit large artificial wetlands (Garnett & Crowley 2000) although threats such as the destruction or modification of habitat, particularly by drainage works, clearing, cropping or burning are noted (Marchant & Higgins 1990).

Maundia triglochinoides

Maundia triglochinoides is a perennial plant with rhizomes about 5mm thick and emergent tufts of leaves arising along their length. Leaves are triangular in cross section, to 80 cm long, 5 - 10mm wide. Inflorescence is up to 10cm long and 2.5 cm wide. Carpels (female parts of flower) are 6 - 8mm long, sessile, each with a spreading beak (Harden, 1993). This species is found along the NSW coast and southern Queensland. There are historic records

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of this species occurring as far south as Sydney, however it is presumed extinct south of Wyong (DECC 2005). *M. triglochinoides* is listed as vulnerable under the TSC Act.

M. triglochinoides grows in swamps, creeks or shallow freshwater 30 - 60 cm deep on heavy clay and low nutrients and it is often associated with wetland species e.g. *Triglochin procerum*. Flowering occurs during warmer months (November to January). The plant is likely to be wind pollinated. Long distance dispersal is through seed and root tubers, which are probably dispersed by water. The plant spreads vegetatively, with tufts of leaves arising along the rhizomes (DECC, 2005b). The main threats to this species are loss and fragmentation of habitat, changes in hydrology and water quality, and weed invasion (DECC 2008).

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APPENDIX 2. SUITABILITY OF HABITAT AT TARGET DAMS

GGBF = Green and Golden Bell Frog (*Litoria aurea*); GTF = Green-thighed Frog (*Litoria brevipalmata*); BBD = Blue-billed Duck (*Oxyura australis*). Cells highlighted red indicate dams that were not surveyed in 2014 due to access restrictions.

Dam Number	*M. triglochinoides*	GGBF	GTF	BBD
1	✓	✓	✓	
3	✓	✓		
4	✓	✓		
5	✓	✓		
6	✓	✓		
7	✓	✓		✓
11	✓	✓		
12	✓			
13	✓	✓		
14	✓			✓
15	✓	✓		
16	✓	✓		✓
18	✓	✓		
19	✓	✓		
20	✓	✓		
21	✓	✓		
22	✓	✓		
23	✓	✓		
25	✓	✓		
26	✓	✓		
27	✓	✓		
28	✓	✓		✓
29	✓			
31	✓			
32	✓	✓		
33	✓			
34	✓			
35	✓	✓		
36	✓			
38	✓	✓		
39	✓	✓		
40	✓	✓		
41	✓	✓		
42	✓	✓		
45	✓	✓		
46	✓	✓		
47	✓	✓		

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Dam Number	*M. triglochinoides*	GGBF	GTF	BBD
48	✓	✓		
51	✓	✓		
53	✓	✓		
54	✓	✓		
57	✓	✓		
58	✓	✓		
59	✓			
61	✓	✓		
62	✓	✓		
85	✓	✓		
87			✓	
91	✓	✓		
92	✓	✓		
93	✓			
99	✓			
103	✓			
107	✓			
112	✓	✓		
121	✓			
122	✓	✓		
123	✓	✓		
125	✓	✓		
126	✓	✓		
128	✓			
129	✓	✓		
130	✓	✓		
131	✓			
132	✓			
133	✓			
134	✓			
142	✓	✓		
144	✓	✓		
148	✓	✓		
149	✓	✓		
150	✓			
151	✓		✓	
152	✓	✓		
153	✓	✓		
154	✓	✓		
155	✓			
157	✓	✓		
160	✓	✓		
161	✓	✓		
162	✓	✓		
163	✓	✓		
164	✓			
167	✓	✓		

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Dam Number	*M. triglochinoides*	GGBF	GTF	BBD
168	✓	✓		
169	✓	✓		
Total with Suitable Habitat	85	63	2	4
Total Surveyed	57	50	2	2

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APPENDIX 3. AMPHIBIAN SPECIES RECORDED IN EACH DAM SURVEYED

'x' – indicates presence NA – No available access Dam = Dam Number Survey Year = 2008, 2009, 2010, 2011, 2012, 2013, 2014

DAM	*Litoria fallax* (Dwarf Green Tree Frog)							*Litoria peronii* (Emerald-spotted Tree Frog)							*Litoria tyleri* (Southern Laughing Frog)							*Litoria latopalmata* (Broad-palmed Frog)						
Survey Year	8	9	10	11	12	13	14	8	9	10	11	12	13	14	8	9	10	11	12	13	14	8	9	10	11	12	13	14
1	x	x	x	x	x	x	NA	x		x	x	x	x	NA	x		x	x	x	x	NA					x		NA
3	x	x		x	x	x	x		x																x	x		
4	x	x	x		x	x	x				x	x	x						x			x	x		x	x		x
5	x	x	x	x	x	x	x		x		x	x	x		x										x			
6	x	x	x	x	x	x	NA						x	NA							NA				x		x	NA
7	x	x	x	x	x	x	x				x		x		x										x	x		x
11	x	x	x	x	x	x	x	x	x			x	x	x	x				x	x								
13	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x				x	x	x		x
15	x	x	x	x	x	x	x	x	x				x							x		x	x			x	x	
16	x		x	x	x	x	NA			x		x	NA	NA				x	x	NA	NA	x		x			NA	NA
18	x	x	x	x	x	x	x	x	x	x	x	x			x			x	x							x		
19	x	x	x	x	x	x	x																					
20	x	x	x	x	x	x	x	x		x	x		x	x	x		x		x						x	x	x	x
21	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x					x	x	x	x	x
22	x	x	x	x	x	x	x					x					x					x	x	x	x			
23	x	x	x	x	x	x	x		x								x			x		x	x	x				x
25	x	x	x	x	x	x	x	x			x	x													x	x		
26	x		x	x	x	x	x	x			x	x						x										
27	x	x	x	x	x	x	x	x		x	x	x	x		x		x		x					x	x	x		

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DAM	*Litoria fallax* (Dwarf Green Tree Frog)							*Litoria peronii* (Emerald-spotted Tree Frog)							*Litoria tyleri* (Southern Laughing Frog)							*Litoria latopalmata* (Broad-palmed Frog)						
Survey Year	8	9	10	11	12	13	14	8	9	10	11	12	13	14	8	9	10	11	12	13	14	8	9	10	11	12	13	14
28	x		x	x	x	x	NA			x		x	x	NA				x	x		NA	x		x	x			NA
32	x	x	x	x	x	x	x	x		x	x	x			x		x		x	x		x		x	x	x	x	x
35	x		x	x	x	x	x										x	x		x		x		x				
38	x	x	x	x	x	x	x	x		x	x	x	x									x		x	x	x	x	x
39	x	x	NA	N/A	x	x	NA	x	x	NA	NA	x	x	NA	x		NA	NA			NA	x		NA	NA	x	x	NA
40	x	x	x	x	x	x	nil	x		x	x		x					x		x		x	x	x	x	x	x	
41	x	x	x	x	x	x	NA		x	x	x	x	x	NA				x		x	NA	x	x	x			x	NA
42	x		x	x		x	x	x		x	x	x	x	x	x					x		x	x	x	x		x	x
45	x	x	NA	N/A	x	x	NA	x		NA			x	NA	x	x	NA	NA	x	x	NA	x	x	NA	NA		x	NA
46	x	x	NA	N/A	x	x	NA	x		NA	NA	x		NA	x		NA	NA		x	NA	x	x	NA	NA	x		NA
47			x	x	x	x	NA					x		NA				x	x	x	NA						x	NA
48	x	x	x	x	x	x	x	x		x	x				x		x	x		x		x		x			x	
51	x	x	x	x	x	x	x										x					x		x		x		x
53	x	x	x	x		x	NA							NA				x		x	NA						x	NA
54	x			x	x		NA	x		x				NA							NA	x		x	x	x	x	NA
57	x		x	x	x	x	x			x	x	x	x	x						x				x	x	x	x	x
58			x	x	x	x	x			x	x	x						x						x	x	x	x	x
61	x	x	x	x	x	x	x			x				x	x		x	x	x	x				x	x			
62	x	x	x	x	x	x	x		x	x	x		x			x				x				x				x
85	x	x	x	x	x	x	x	x			x	x	x	x				x	x	x						x		x
87																											x	x
91							nil						x							x						x		
92	x	x	x	x	x	x	NA	x	x	x		x	x	NA	x		x	x		x	NA						x	NA
93					x	x	NA					x		NA					x	x	NA							NA
112	x	x	x	x	N/A	x	NA		x	x	x	N/A	NA	NA	x	x	x	x	N/A	NA	NA			x		N/A	NA	NA
122	x	x	x	x	x	x	x																					

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DAM	*Litoria fallax* (Dwarf Green Tree Frog)							*Litoria peronii* (Emerald-spotted Tree Frog)							*Litoria tyleri* (Southern Laughing Frog)							*Litoria latopalmata* (Broad-palmed Frog)						
Survey Year	8	9	10	11	12	13	14	8	9	10	11	12	13	14	8	9	10	11	12	13	14	8	9	10	11	12	13	14
123	x	x	x	x	x	x	x										x	x		x								
125	x		x	x	x	x	x			x		x					x	x		x				x			x	
126	x	x	x	x	x	x	x								x		x	x	x	x								
129	x	x	x	x	x	x	x								x		x	x		x								
130	x	x	x	x	x	x	x		x										x								x	
131	NA	NA	NA	NA	x	x	x	NA	NA	NA	NA		x		NA	NA	NA	NA	x	x		NA	NA	NA	NA			
142	x	x	x	x	x	x	nil				x																x	
144	x	x		x	x	x	nil		x		x	x	x			x												
148	x	x	x	x	x	x	NA					x		NA			x	x	x		NA	x	x			x	x	NA
149	x	x	x	x	x	x	NA							NA						x	NA			x	x		x	NA
151	x	x	x	x	x	x	x		x			x	x				x			x	x							
152	x	x		x	x	x	x	x	x	x	x	x	x		x			x	x	x		x			x	x		x
153	x			x	x	x	x	x		x	x	x	x	x			x	x	x	x	x	x			x	x		
154	x	x	x	x	x	x	x				x		x					x							x			
157					x	x	x						x									x	x		x			x
160	x	x	x	x	x	x	x	x		x	x	x	x	x			x	x				x	x	x	x	x	x	x
161	x		x	x	x	x	NA	x		x	x	x		NA	x		x	x	x	x	NA	x		x	x	x	x	NA
162			x	x	x	x	NA			x		x		NA	x		x	x	x	x	NA			x	x			NA
163	x		x	x		x			x								x								x			
167	x			x	x	x	x	x										x										
168	x		x	x	x	x													x							x		
169			x	x		x												x						x	x		x	

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DAM	*Litoria nasuta* (Rocket Frog)							*Litoria verreauxii* (Whistling Tree Frog)							*Limnodynastes peronii* (Striped Marsh Frog)							*Limnodynastes tasmaniensis* (Spotted Grass Frog)						
Survey Year	8	9	10	11	12	13	14	8	9	10	11	12	13	14	8	9	10	11	12	13	14	8	9	10	11	12	13	14
1				x			NA	x	x		x	x	x		x		x				NA							
3											x		x		x					x								
4												x	x						x									
5										x	x		x								x							
6							NA	x	x		x		x			x	x	x			NA							
7								x	x			x	x		x			x		x	x				x			
11								x					x			x			x		x	x		x				
13																								x	x			
15															x	x	x				x							
16						NA	NA		x	x			NA		x				x	NA	NA							NA
18									x		x	x	x															
19									x				x															
20													x		x		x											
21										x					x													
22										x					x	x	x	x		x	x							
23										x					x		x	x	x	x	x			x				
25								x	x	x	x		x		x	x		x						x	x			
26												x	x						x									
27								x	x	x		x	x		x	x	x	x		x	x							
28							NA			x			x	NA	x		x	x	x		NA							NA
32										x					x	x			x									
35										x							x	x	x	x	x							
38																		x	x			x		x				
39			NA	NA			NA			NA	NA			NA			NA	NA	x		NA			NA	NA			NA
40											x				x	x	x			x		x	x	x	x			
41							NA			x				NA		x			x		NA							NA

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DAM	*Litoria nasuta* (Rocket Frog)							*Litoria verreauxii* (Whistling Tree Frog)							*Limnodynastes peronii* (Striped Marsh Frog)							*Limnodynastes tasmaniensis* (Spotted Grass Frog)						
Survey Year	8	9	10	11	12	13	14	8	9	10	11	12	13	14	8	9	10	11	12	13	14	8	9	10	11	12	13	14
42									x											x		x		x	x			
45			NA	NA			NA			NA	NA			NA	x		NA	NA	x	x	NA	x	x	NA	NA			NA
46			NA	NA			NA			NA	NA			NA	x		NA	NA		x	NA			NA	NA			NA
47							NA							NA				x	x	x	NA							NA
48										x												x		x				
51										x								x	x									
53							NA						x	NA	x	x	x	x	x	x	x							NA
54							NA			x				NA							NA	x		x				NA
57																						x		x				
58																				x		x						
61																	x		x		x				x			
62																x					x							
85																	x		x	x	x							
87																				x								
91													x		x		x	x		x								
92							NA		x					NA		x					NA							NA
93							NA							NA					x		NA							NA
112					N/A	NA	NA			x		N/A	NA	NA			x	x	N/A	NA	NA			x		N/A		NA
122															x		x	x				x		x	x			
123																								x				
125										x		x			x		x	x	x	x		x						
126															x		x	x						x				
129																		x	x	x				x				
130																			x	x	x							
131	NA	NA	NA	NA				NA	NA	NA	NA								x									

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DAM	*Litoria nasuta* (Rocket Frog)							*Litoria verreauxii* (Whistling Tree Frog)							*Limnodynastes peronii* (Striped Marsh Frog)							*Limnodynastes tasmaniensis* (Spotted Grass Frog)						
Survey Year	8	9	10	11	12	13	14	8	9	10	11	12	13	14	8	9	10	11	12	13	14	8	9	10	11	12	13	14
142													x						x									
144								x	x	x																		
148							NA						x	NA	x						NA							NA
149							NA						x	NA				x		x	NA				x			NA
151		x						x					x		x		x	x	x	x	x							
152													x															
153													x				x			x	x		x					
154	x	x						x									x	x	x		x							
157													x					x						x				
160																					x	x	x	x				
161							NA			x			x	NA	x		x	x			NA							NA
162							NA	x		x			x	NA	x			x	x	x	NA							NA
163																					x			x				
167																x	x	x	x	x	x							
168										x			x		x			x	x	x	x	x						
169																					x			x	x			

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DAM	*Uperoleia fusca* (Dusky Toadlet)							*Uperoleia laevigata* (Smooth Toadlet)							*Crinia signifera* (Common Eastern Froglet)							*Adelotus brevis* (Tusked Frog)						
Survey Year	8	9	10	11	12	13	14	8	9	10	11	12	13	14	8	9	10	11	12	13	14	8	9	10	11	12	13	14
1	x		x				NA	x		x	x			NA				x			NA							NA
3			x					x	x	x		x				x	x											
4			x	x				x	x	x		x			x	x												
5				x				x							x	x	x											
6			x				NA	x						NA	x	x	x	x	x		NA							NA
7				x											x	x	x											
11								x	x	x	x				x		x											
13			x	x				x							x													
15								x							x	x		x										
16							NA							NA	x	x	x				NA							NA
18								x			x				x	x	x											
19																x	x											
20								x		x					x	x												
21								x							x	x												
22								x							x													
23															x	x	x		x									
25			x	x				x		x					x	x	x											
26								x	x						x	x	x											
27								x									x											
28							NA				x			NA	x	x					NA							NA
32																												
35								x				x				x												
38								x		x					x													
39			NA	NA			NA			NA	NA			NA		x	NA	NA			NA			NA	NA			NA
40								x	x	x	x				x	x												
41							NA	x	x		x	x		NA	x	x	x				NA							NA

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DAM	*Uperoleia fusca* (Dusky Toadlet)							*Uperoleia laevigata* (Smooth Toadlet)							*Crinia signifera* (Common Eastern Froglet)							*Adelotus brevis* (Tusked Frog)						
Survey Year	8	9	10	11	12	13	14	8	9	10	11	12	13	14	8	9	10	11	12	13	14	8	9	10	11	12	13	14
42																x												
45			NA	NA			NA	x		NA	NA	x		NA			NA	NA			NA			NA	NA			NA
46			NA	NA			NA			NA	NA			NA			NA	NA			NA			NA	NA			NA
47							NA							NA			x				NA							NA
48								x	x																			
51															x	x												
53							NA	x						NA		x					NA							NA
54							NA	x	x	x	x			NA		x					NA							NA
57																x												
58											x				x	x												
61								x	x	x	x				x	x	x											
62								x							x	x												
85																												
87																												
91																												
92							NA	x			x			NA		x	x				NA							NA
93							NA							NA							NA							NA
112			x		N/A		NA	x	x			N/A		NA					N/A		NA					N/A		NA
122								x		x						x	x	x										
123																												
125			x					x			x				x			x							x			
126			x					x		x	x					x	x											
129			x	x				x		x	x					x	x	x										
130											x				x	x	x											
131																												
142								x		x																		

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DAM	*Uperoleia fusca* (Dusky Toadlet)							*Uperoleia laevigata* (Smooth Toadlet)							*Crinia signifera* (Common Eastern Froglet)							*Adelotus brevis* (Tusked Frog)						
Survey Year	8	9	10	11	12	13	14	8	9	10	11	12	13	14	8	9	10	11	12	13	14	8	9	10	11	12	13	14
144								x	x			x				x	x											
148							NA				x			NA		x					NA							NA
149							NA				x			NA		x					NA							NA
151											x	x			x		x											
152		x	x	x				x	x	x																		
153		x	x						x	x	x	x		x	x	x												
154								x	x						x	x	x	x										
157																x												
160								x		x	x	x		x														
161							NA	x	x		x	x		NA		x					NA							NA
162			x	x			NA	x	x		x			NA	x	x		x			NA							NA
163															x	x												
167								x	x						x	x	x											
168			x					x	x	x					x	x	x											
169										x	x			x				x										

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Number	Number of amphibian species recorded each year						
	2008	2009	2010	2011	2012	2013	2014
D1	7	2	6	7	5	6	NA
D3	3	4	3	3	3	4	1
D4	4	4	3	3	7	5	2
D5	4	3	3	5	2	4	2
D6	4	4	4	5	2	4	NA
D7	5	3	2	6	3	5	3
D11	7	4	4	2	4	6	3
D13	5	3	6	6	4	3	3
D15	6	5	2	2	2	5	2
D16	4	2	5	2	4	NA	NA
D18	5	4	3	5	5	2	1
D19	1	3	2	1	1	3	1
D20	6	2	5	3	3	4	3
D21	6	4	5	4	4	3	3
D22	5	3	5	3	2	2	2
D23	4	4	7	2	3	4	3
D25	6	4	6	7	3	3	1
D26	4	2	2	3	4	2	1
D27	6	3	7	4	5	5	2
D28	4	1	5	5	4	4	NA
D32	5	2	5	3	5	5	2
D35	3	1	5	3	3	5	2
D38	6	1	5	4	4	3	2
D39	4	3	NA	NA	4	3	NA
D40	7	6	6	7	2	6	0
D41	4	6	5	4	4	6	NA
D42	5	3	4	4	1	5	3
D45	7	4	NA	NA	4	6	NA
D46	5	2	NA	NA	3	3	NA
D47	0	0	2	3	4	5	NA
D48	6	2	6	3	1	3	1
D51	3	2	4	2	3	1	2
D53	3	3	2	3	1	8	1
D54	5	2	5	3	2	4	NA
D57	2	1	4	3	3	6	3
D58	2	1	3	5	3	4	2
D61	4	3	7	5	3	3	3

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Number	Number of amphibian species recorded each year						
	2008	2009	2010	2011	2012	2013	2014
D62	3	5	3	2	1	4	3
D85	2	1	2	3	5	4	3
D87	NA	NA	NA	0	0	4	1
D91	1	0	1	1	1	6	0
D92	4	5	4	2	2	6	NA
D112	3	4	8	5	NA	2	NA
D122	4	2	5	4	1	NA	1
D123	1	1	3	2	1	4	1
D125	5	0	7	6	4	2	1
D126	4	2	7	4	2	6	1
D129	3	2	6	6	2	4	1
D130	2	3	2	2	3	5	2
D131	NA	NA	NA	NA	3	4	1
D142	2	1	2	2	2	3	0
D144	3	6	2	2	3	3	0
D148	3	3	2	3	4	3	NA
D149	1	2	2	5	1	6	NA
D151	4	3	4	3	4	7	3
D152	5	4	3	5	4	7	2
D153	4	4	5	5	5	5	5
D154	5	4	3	6	2	6	2
D157	1	2	1	2	1	3	2
D160	5	3	6	5	4	4	5
D161	6	2	6	6	5	5	NA
D162	5	2	6	7	4	5	NA
D163	2	2	3	2	0	5	1
D167	4	3	2	3	2	2	2
D168	5	2	5	2	4	3	1
D169	0	0	4	6	0	4	2
Mean per year	**3.85**	**2.64**	**3.82**	**3.5**	**2.88**	**4.25**	**1.88**

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APPENDIX 4. BIRD SPECIES ABUNDANCE AT TARGET DAMS

Scientific Name	Common Name	Dam No. 7							Dam No. 14							Dam No. 16							Dam No. 28						
		2008	2009	2010	2011	2012	2013	2014	2008	2009	2010	2011	2012	2013	2014	2008	2009	2010	2011	2012	2013	2014	2008	2009	2010	2011	2012	2013	2014
Anhinga novaehollandiae	Australasian Darter					1	1	1								1						NA				1	1	1	NA
Tachybaptus novaehollandiae	Australasian Grebe				1		1			2		1	2				4		1	1		NA	2	3			2		NA
Cracticus tibicen	Australian Magpie																					NA						1	NA
Pelecanus conspicillatus	Australian Pelican																					NA		1					NA
Corvus coronoides	Australian Raven						3															NA						1	NA
Acrocephalus australis	Australian Reed Warbler				h	1	1															NA		h			1		NA
Chenonetta jubata	Australian Wood Duck	6				4			6	4		10		10	8	10	4					NA	26	3	5				NA
Geopelia humeralis	Bar-shouldered Dove												1							1		NA							NA
Manorina melanophrys	Bell Miner												10	20	3						5	NA							NA
Coracina novaehollandiae	Black-faced Cuckoo-shrike							1						1								NA						1	NA
Cygnus atratus	Black Swan	1						2											1			NA			5	1			NA
Falco berigora	Brown Falcon																					NA						1	NA
Ardea ibis	Cattle Egret																		1		1	NA						4	NA
Anas castanea	Chestnut Teal								4	40				2			10			1	10	NA	2				1		NA
Gallinula tenebrosa	Dusky Moorhen		2	2		1						2	4	1		2	2		1	1		NA	3	2	1	2	1	2	NA
Platycercus eximius	Eastern Rosella						2															NA							NA
Parrot Hybrid	Eastern Rosella/Mallee Ringneck													2								NA							NA
Acanthorhynchus tenuirostris	Eastern Spinebill						1															NA							NA

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Scientific Name	Common Name	Dam No. 7							Dam No. 14							Dam No. 16							Dam No. 28						
		2008	2009	2010	2011	2012	2013	2014	2008	2009	2010	2011	2012	2013	2014	2008	2009	2010	2011	2012	2013	2014	2008	2009	2010	2011	2012	2013	2014
Eopsaltria australis	Eastern Yellow Robin												1	1								NA							NA
Psophodes olivaceus	Eastern Whipbird														1							NA							NA
Fulica atra	Eurasian Coot	4	1	2	8	11	3	2						1	1		2					NA	2	1			1	4	NA
Pachycephala pectoralis	Golden Whistler													1								NA							NA
Phalacrocorax carbo	Great Cormorant			1										1								NA							NA
Rhipidura albiscapa	Grey Fantail						2							1	2						2	NA						1	NA
Anas gracilis	Grey Teal									60					6		6					NA	5						NA
Aythya australis	Hardhead																1			1	4	NA	3					1	NA
Gallinago hardwickii	Latham's Snipe							2														NA							NA
Dacelo novaeguineae	Laughing Kookaburra							1						1							1	NA						1	NA
Myiagra rubecula	Leaden Flycatcher													1								NA							NA
Meliphaga lewinii	Lewin's Honeyeater																			1		NA							NA
Phalacrocorax sulcirostris	Little Black Cormorant	4	2	2	3	3	2							1	1						2	NA	2	3	2	3			NA
Phalacrocorax melanoleucos	Little Pied Cormorant		1		2	1	1															NA		1					NA
Vanellus miles	Masked Lapwing		1			1	1							1		2						NA						2	NA
Grallina cyanoleuca	Magpie-lark						1	1													1	NA							NA
Nycticorax caledonicus	Nankeen Night Heron						2													1		NA		1			1		NA
Oriolus sagittatus	Olive-backed Oriole						1						1									NA							NA
Anas superciliosa	Pacific Black Duck	1	4						1	72		1	6		4	5	5			3		NA	2	10		10			NA
Phalacrocorax varius	Pied Cormorant													1		1						NA						1	NA
Porphyrio porphyrio	Purple Swamphen	2	10	10	2	1		5						8					1		6	NA	2	2	2			7	NA
Rhipidura rufifrons	Rufous Fantail												2		1							NA							NA
Todiramphus sanctus	Sacred Kingfisher	1		1						1	1	h	1		1			1				NA			h				NA
Malurus cyaneus	Superb Fairy-wren						1								2					2	1	NA					1		NA

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Scientific Name	Common Name	Dam No. 7							Dam No. 14							Dam No. 16							Dam No. 28						
		2008	2009	2010	2011	2012	2013	2014	2008	2009	2010	2011	2012	2013	2014	2008	2009	2010	2011	2012	2013	2014	2008	2009	2010	2011	2012	2013	2014
Circus approximans	Swamp Harrier	2														1						NA							NA
Hirundo neoxena	Welcome Swallow						1						8		12					2		NA							NA
Haliastur sphenurus	Whistling Kite			1										2								NA							NA
Artamus leucorynchus	White-breasted Woodswallow							2														NA							NA
Haliaeetus leucogaster	White-bellied Sea-Eagle												1								3	NA						3	NA
Egretta novaehollandiae	White-faced Heron	2	1											1								NA			1				NA
Rhipidura leucophrys	Willie Wagtail					1							1		2							NA					1		NA
Lichenostomus chrysops	Yellow-faced Honeyeater												1									NA						8	NA
Zosterops lateralis	Silvereye													1								NA							NA
Total individuals recorded on each dam		23	22	19	16	25	24	17	11	179	1	14	39	60	44	22	34	1	5	14	36	0	49	27	16	17	10	40	0
No. of species recorded on each dam		9	8	7	6	10	16	9	3	6	1	5	13	21	13	7	8	1	5	10	11	0	10	11	7	5	9	18	0

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APPENDIX 5: CONTRIBUTIONS AND QUALIFICATIONS OF KLEINFELDER STAFF

Name	Qualification	Title	Contribution
Gayle Joyce	B. Sc (Forestry) (Hons)	GIS Officer	Map preparation
Luke Foster	BSc Env & Mgt MEnvSci&Mgt (Wildlife Ecology)	Ecologist	Amphibian Survey
Feach Moyle	BSc (Hons) ADAS	Principal Ecologist	Bird surveys, internal technical and peer review
Mark Dean	B. Env. Sc. & Mgt. (Biol.).	Ecologist	Amphibian Survey & Report Writing

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APPENDIX 6. LICENSING

Kleinfelder employees involved in the current study are licensed or approved under the *National Parks and Wildlife Act 1974* (License Number: SL100730, Expiry: 31st March 2015) and the *Animal Research Act 1985* to harm/trap/release protected native fauna and to pick for identification purposes native flora and to undertake fauna surveys.

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APPENDIX 7. PHOTOS

Emerald Spotted Tree Frog *Litoria peronii*

Eastern Dwarf Tree Frog *Litoria fallax*

Broad Palmed Rocket Frog *Litoria latopalmata*

Smooth Toadlet *Uperoleia laevigata*

Striped Marsh Frog *Limnodynastes peronii*

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